

US NRC Activities on Advanced Manufacturing Technologies

Wendy Reed
US Nuclear Regulatory Commission

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The AM Team

- Project Team

- Carolyn Fairbanks, Technical Lead
- Robert Davis
- Mark Yoo, RES lead
- Matthew Hiser
- Bruce Lin
- Isaac Anchondo-Lopez, Project Manager

- Supporting Staff

- Meg Audrain
- Amy Hull
- Shah Malik

- Technical Advisory Team

- Allen Hiser
- David Rudland
- Robert Tregoning

- Steering Committee

- Angie Buford (Chair)
- Steve Ruffin
- Raj Iyengar
- Matthew Mitchell

Outline

- 2 Part Presentation
- NRCs efforts to “get ready” for advanced manufacturing technologies
 - Driver
 - Action Plan
 - Technical Preparedness Activities
- NRC’s support of WGSAR efforts
 - Purpose of Survey
 - Development
 - Analysis of Responses



Drivers for NRC Activities

- Variety of stakeholders are working towards more widespread use in both existing and future nuclear applications
- Vendors and licensees/applicants
 - Identifying candidate applications
 - Developing technical basis for gaining regulatory acceptance

First US NPP Application of Additive Manufacturing

- Thimble Plugging Device
 - Installed in March 2020 in Byron Unit 1
 - 316L stainless steel -LPBF
 - Very low safety significant component (Non-ASME B&PV Code class)
 - PWR environment with irradiation
 - Installation done in accordance with 10 CFR 50.59, which does not require prior NRC approval



NRC Action Plan for AMTs

Objectives of Action Plan

- Assess safety significant differences between AMTs and traditional manufacturing processes
- Prepare staff to address industry implementation of AMT-fabricated components through the 10 CFR 50.59 process.
- Identify and address AMT characteristics pertinent to safety, that are not managed or addressed by codes, standards, regulations, etc.
- Provide guidelines and tools for NRC review consistency
- Provide transparency to stakeholders on the process for AMT approvals.

Revision 1 was published in June 2020 ([ML19333B980](#))

Task 1 - Technical Preparedness Activities

Subtask 1A: AMT Processes under Consideration

- Perform a technical assessment of selected AMTs
- Gap assessment for each selected AMT vs traditional manufacturing techniques

Subtask 1B: Inspection and NDE

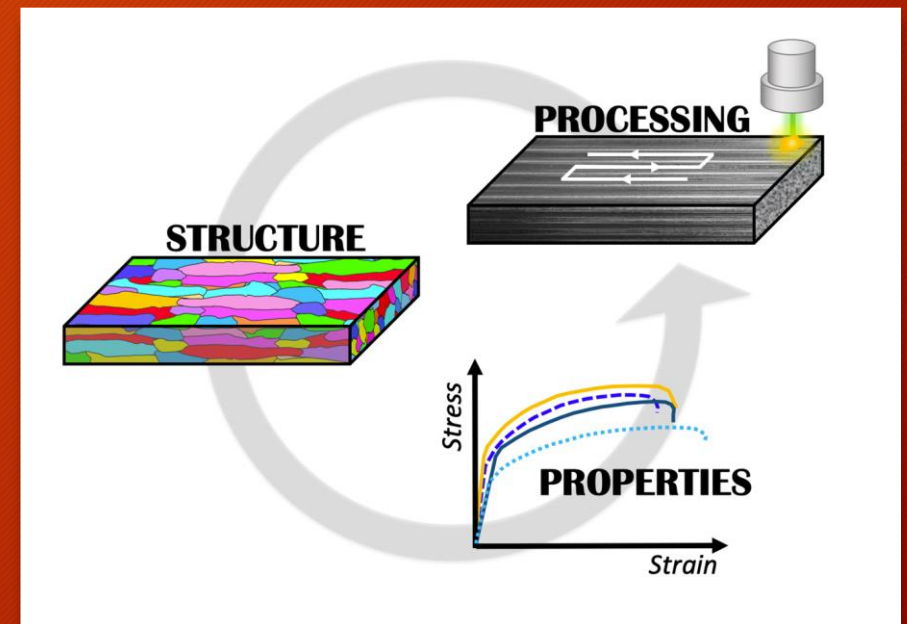
- Assess the state of technologies in the testing and examination of AMTs
- Will inform staff decisions related to use of NDE on AMT-fabricated components

Subtask 1C: Modeling and Simulation of Microstructure and Properties

- Evaluate modeling and simulation tools used to predict the initial microstructure, material properties and component integrity of AMT components
- Identify existing gaps and challenges that are unique to AMT compared to conventional manufacturing processes

Subtask 1C: Modeling and Simulation of Microstructure and Properties

- Two report series
- First report summarizes the current state-of-the art in predicting the initial microstructure of materials resulting from AMTs
- Key Conclusions:
 - Better methods of length- and time-scale bridging for the physics-based methods recommended
 - Collation or generation of larger microstructural databases for the data-driven methods
 - Development of community accepted validation benchmarks for the different AMTs of interest
- Second report surveys the current state of modeling and simulation methods for predicting key material properties
- Key gaps:
 - the lack of automated methods for bridging length and time scales
 - difficulties in ab initio modeling of new materials
 - a general lack of application of AMTs and materials for nuclear applications



Current and Future Activities

Assessment of additional AMTs

- Arc-DED, diode laser cladding

NDE of AMT components

- Confirmatory testing and examination of AMT components
- Verification of NDE methods

Data and modeling for qualification:

- In-process NDE techniques and capabilities
- Capturing and integrating information from data and modeling to support qualification

Materials performance of AMT components

- Assess microstructure differences in AMT components for impact to aging mechanisms

Summary

NRC began preparing for the adoption of advanced manufacturing technologies in nuclear applications in 2017 and has taken a proactive engagement strategy to prepare for implementation of AMT components.

The NRC has completed its initial set of technical and regulatory deliverables as documented in Revision 1 of the AMT Action Plan.

- Developed the technical information, knowledge, and tools
- Developed draft regulatory framework for AMT submittals
- Conducted communications and KM activities to integrate information from external stakeholders and be transparent in NRC activities

The NRC will continue to further technical preparedness, regulatory preparedness, and communications and KM activities to prepare for industry implementation of AMTs

Common Regulatory Practices to Ensure Appropriate Qualification and Through Life Performance of Materials in Advanced Reactors: Survey Results

Working Group for Safety of Advanced
Reactors

OECD-NEA -- CNRA



Purpose of Survey



address licensing and regulatory considerations for materials and components for advanced reactors



future vision on materials qualification and performance management



current regulatory practices, technical approaches, methods and models used to ensure appropriate

Scope of Survey



pertinent regulatory requirements and technical approaches



monitoring and surveillance programs



Modeling and simulation efforts relating to qualification and materials performance

Survey Development Team

- United States Nuclear Regulatory Commission (lead)
- Office for Nuclear Regulation (UK)
- European Commission - Joint Research Centre

Survey Overview

Mixture of multiple choice and open-ended questions



3 main categories:

Regulatory Structure

Materials Qualification

Lifetime Performance

Questions on Advanced Manufacturing

- Do you see the need for separate qualification procedures for components made by advanced manufacturing technologies?
- Which advanced manufacturing techniques do you see being deployed in advanced reactors in the next decade?
- Please select three techniques that will have greatest needs for qualification/approval in the manufacture of advanced reactor designs
- What do you see as a gap in the qualification and/or regulatory approval process of safety-related nuclear components fabricated from advanced manufacturing
- In your country, are new component test facilities being planned, (e.g., test beds with coolant loops), or existing test facilities being enhanced to better support qualification of advanced manufactured components?
- Would regulators consider the code qualification of a component rather than the code qualification of a material for advanced manufacturing methods?

Qualification of AM Components

21. Would you qualify an AM component rather than a material?

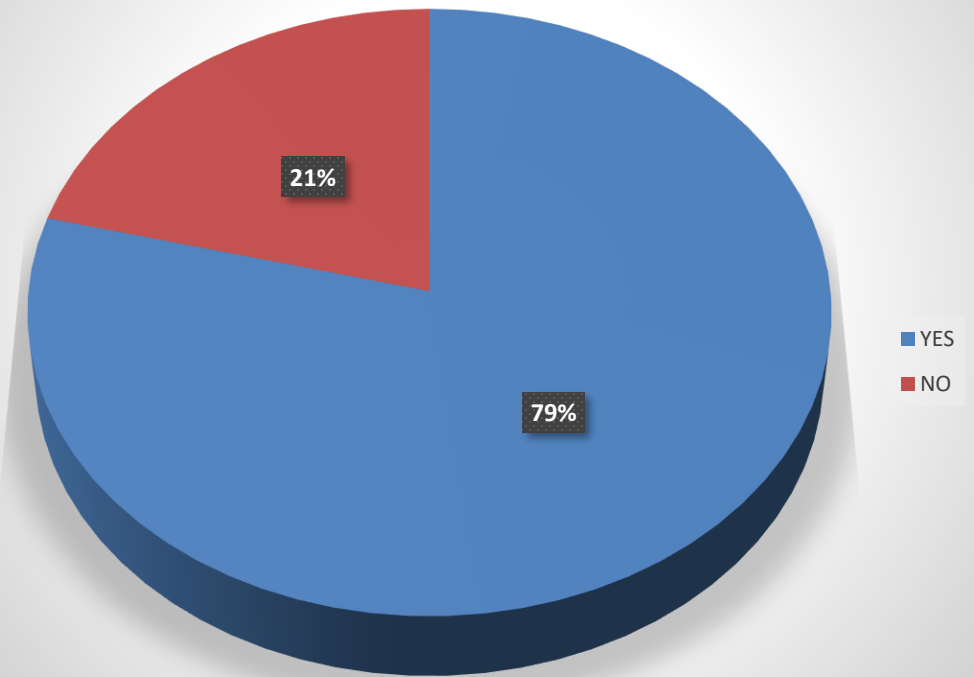


22. If yes, is AM component qualification a part of Regulatory Framework?



Would your organization consider the use of modeling and simulation to reduce the amount of long-term testing data required in a licensee application?

Number of Respondents supportive of modeling and simulation to reduce need for long term test data



Conclusions Regarding AM



Responses show an openness to considering new technologies



Codes and standards preferable, but flexible to alternative qualification approaches



Modeling and simulation could be considered to fill in data gaps



Several new test facilities being planned or built to test AM components

Additional Information

NRC Public Site for AMTs

<https://www.nrc.gov/reactors/power/amts.html>

Deliverables - Task 1

Subtask	Actions/Deliverables	Status
1A AMT processes under consideration	Additive Manufacturing (AM) – Laser Powder Bed Fusion	Complete - ML20351A292
	AM – Directed Energy Deposition (DED)	Complete - ML21301A077
	Cold Spray	Complete - ML21263A105
	Powder Metallurgy (PM) – Hot Isostatic Pressing (HIP)	Complete - ML22134A437
	Electron Beam (EB) welding	Complete - ML22143A927
1B Inspection and NDE	NDE gap analysis	Complete - ML20349A012
1C Modeling and Simulation of Microstructure	M&S gap analysis to predict microstructures	Complete - ML20269A301
	ANL M&S gap analysis to predict material performance	Complete - ML20350B550

Deliverables - Tasks 2 and 3

Subtask f	Actions / Deliverables	Status
2A 50.59 process	Finalize document incorporating feedback from Regional staff regarding the 10 CFR 50.59 process	Complete - ML21200A222
2B Assessment of regulatory guidance	Path forward on guidance development or modification	Complete - ML20233A693
2C AMT Guidance Document	Draft AMT Review Guidelines	Complete - ML21074A037
	Draft Guidelines Documents for specific AMTs	AM-Laser Powder Bed Fusion - ML21074A040 AM-Laser-Directed Energy Deposition - ML22143A950 Cold Spray - ML22143A950
3D Workshop	Hold public workshop	Complete - Public Meeting Summary: ML20357B071 RIL: Part 1 Part 2